Hybrid SNCR/In-Duct SCR System

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Summary

A novel Hybrid system has been developed that provides high NOx removal efficiency at a cost that is typically 65 - 75% of the cost of a conventional full SCR system. The process uses a two stage urea-based SNCR system to provide an initial NOx reduction while operating with high ammonia slip levels. The slip is then consumed in a downstream in-duct SCR reactor that provides for additional NOx reduction while reducing slip to allowable levels. The system has been developed in a collaborative undertaking between Fuel Tech, Inc. and Babcock Power's Riley Power subsidiary.

In prior applications, the Hybrid systems have provided significant improvement in the efficiency of urea chemical utilization, as compared to conventional SNCR, and increased NOx reduction as compared to the performance of the in-duct SCR standing alone. These improvements result in a lowering of the operating costs for the SNCR system. In addition, SO_2 oxidation and gas side pressure drop will be decreased as compared to an equivalent SCR. Used correctly, this lessens the risks associated with both ammonium bisulfate formation and plume opacity associated with SO_3.

The Hybrid Process is a post-combustion NOx reduction method that reduces NOx through a controlled injection of 50% urea solution into the combustion gas path of fossil-fired and waste-fired boilers, furnaces, incinerators, or heaters. The predominant overall reaction of the NOxOUT® SNCR system is described as:

$$CO(NH_2)_2 + 2NO + 1/2\ O_2 \Rightarrow 2N_2 + CO_2 + 2H_2O$$
Urea + Nitrogen Oxide ⇒ Nitrogen + Carbon Dioxide + Water

By injecting the stabilized aqueous solution of urea into the appropriate temperature window of the furnace, the reaction occurs and ammonia is produced. The resultant reagent from this process follows the typical post-combustion SCR process to produce nitrogen and water. The dominant SCR reactions are described as follows:

$$4NO + 4NH_3 + O_2 \longrightarrow 4N_2 + 6H_2O$$
$$NO + NO_2 + 2NH_3 \longrightarrow 2N_2 + 3H_2O$$
Nitrogen Oxide(s) + Ammonia + Oxygen → Nitrogen + Water

$$4\ NO + 4\ HNCO + O_2 \longrightarrow 4\ N_2 + 4\ CO_2 + 2\ H_2O$$
Nitrogen Oxide + Isocyanic Acid + Oxygen ⟶ Nitrogen + Carbon Dioxide + Water

There are substantial benefits gained from the application of the Hybrid Process. These benefits are briefly summarized below:

- Use of non-toxic, non-hazardous chemicals.
- Lower capital cost than SCR systems due smaller catalyst volumes.
- Lower operating costs resulting from enhanced utilization of the urea reagent and simplified catalyst management plans.
- Inherently more effective control of spray patterns and chemical distribution for better mixing with the use of liquid rather than gas-based reagents, thereby resulting in better chemical utilization.

A new utility application is currently in design that will provide 65% overall reduction using a Fuel Tech, Inc. urea-SNCR system with downstream mixing and an in-duct catalyst reactor by Riley Power Inc. The integrated system is being designed through the use of advanced computational fluid dynamics and cold flow modeling techniques.